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DISTRIBUTION OF BIRDS IN RELATION TO VEGETATION ON THE NEW DELHI RIDGE[1]

A. J. GASTON[2]
(With two text-figures)

The resident, breeding, and wintering avifauna of an area of 0.7 Km² of woodland and scrub on the Delhi ridge was studied over a period of three years. The paper describes four main vegetation types, and their distribution in relation to topographic and biotic factors. The bird species found in each are listed.

Species diversity was found to be greatest in dense scrub, the vegetation type least affected by human interference. Species diversity in all habitats was found to be greater in winter than in summer.

The ratio of passerines to non-passerine species was found to be higher in winter than summer.

Turnover of species between winter and summer was found to be highest in woodland habitats, and this may reflect the preponderance of summer visitors amongst the woodland avifauna of the Palaearctic.

Habitat specialisation was found to be greater among non-passerines, but the degree of specialisation was equal when resident passerines were compared with wintering palaearctic passerines.

INTRODUCTION

This paper deals with the ecology of birds on the New Delhi Ridge, describing the vegetation of the area and the distribution of birds in relation to the different vegetation types. Studies were carried out during the period from August 1971 to June 1974 in an area of reserved forest immediately to the west of Rashtrapati Bhavan. Observations were concentrated in about 1 km² of broken, rocky terrain, rising gradually from East and West and bounded to the west by Upper Ridge Road, which roughly follows the crest of the ridge, to the north by Shankar Road and to the south by the edge of Buddha Jayanti Park.

There is no previous work dealing specifi-

[1] Accepted May 1977.

[2] Edward Grey Institute, Dept. of Zoology, South Parks Road, Oxford, England.

cally with the birds of this area, but it is frequently referred to in Hutson's "The Birds about Delhi" (1954), which describes the status around Delhi of most of the species recorded in the present study. A comparison with Hutson's records, and also with the status as described in "The Birds of Delhi and District, Field Check List" (1967) provides much useful information, because many species which are to be seen throughout the year in the moist riverain areas along the River Jumna, 4 miles to the East, occur only at certain seasons in the dry scrub of the ridge.

The data on which the present analysis is based consists of field notes taken during the course of research on *Turdoides* spp. As a result, observations were not systematic, but resulted from casual notes on habitat and feeding niches. Field notes did not specify the four categories of vegetation defined below, but usually consisted of a general description of the vegetation in which the species was encountered. Notes on feeding situations were not always included and these have been filled out from memory. Species were described as residents or summer visitors on the basis of seasonal records summarised elsewhere (Gaston 1978). Only resident species recorded in the study area in at least thirty weeks and summer and winter visitors recorded in at least fifteen weeks during the three years of the study are included. Avian nomenclature follows Ali & Ripley (1968-74) and botanical nomenclature follows Maheshwari (1963).

Structure and vegetation of the study area

A description of the vegetation of the Delhi area is given by Maheshwari (1963), and both he and Donahue (1967) briefly describe the geology and ecology of the Delhi ridge.

The coarse quartzites which form the underlying rocks of the ridge are the Northernmost extension of the Aravalli Hills, which reach moderate elevations in Rajasthan. Although the overall form of the ridge is gently rounded, it is cut by several deeply incised watercourses. These carry water only during rainy season.

Within the study area the ridge reaches a height of 260 m above sea level in the west, sloping to 230 m in the South-East where it is still 60 m above the level of the River Jumna. A profile taken roughly WNW-ESE across the area (Fig. 1) shows it to be stepped, 2 sloping zones being separated by a more or less level one, which may be the result of a structural weakness. The 2 major watercourses are incised in the sloping zones, but meander without incision in the level area. Soil accumulates principally in the level area, and consists of a coarse alluvial sand with a low humus content.

The development of the vegetation is controlled both by the slope, with its effect on the accumulation of soil, and by biotic influences, particularly grazing and wood-chopping.

The effect of biotic factors on the development of vegetation seems to be greatest in the northern part of the area, adjoining Shankar Road. This part is particularly frequented by people in search of firewood. The least disturbed vegetation occurs in the South-West corner of the area.

Fig. 2 shows the distribution of closed canopy woodland within the study area. The broad belt of woodland running through the centre of the area coincides roughly with the extent of the level shelf, and its consequent accumulation of soil. A second alluvial area, in the North-East corner, lies at the foot of the lower slope.

The trees making up the woodland belt increase in species diversity from North to South,

presumably along a gradient of decreasing biotic interference. The dominant species throughout is *Prosopis juliflora*. In the North this is mixed only with *Albizzia* sp. which was probably planted along Shankar Road, but towards the South there is a progressively greater admixture of *Acacia senegal, Acacia leucophloea, Acacia modesta, Prosopis spicigera,* and *Cassia fistula*. The woodland ranges in height from 6-18 m.

A gradient of species diversity is also noticeable in the composition of the woodland shrub layer. The dominant species throughout is *Adhatoda vasica,* mixed in the North with *Capparis sepiaria*. Towards the South there is an increasing amount of *Carissa spinarum, Grewia tenax, Flacourtia indica,* and *Maytenus senegalensis*.

The sloping areas are characterised by the outcropping of much bare rock. In the North they support only scattered trees, mainly *Prosopis juliflora,* and the perennial vegetation is dominated by stunted clumps of the prickly *Zizyphus nummularia,* growing up to 1 m in height. Towards the South-West a taller scrub composed of *Carissa spinarum, Securinega leucopyrus, Dichrostachys cinerea, Zizyphus mauritiana,* and *Flacourtia indica* develops with scattered patches of *Anogeissus pendula* woodland, up to 5 m high. *Butea monosperma*

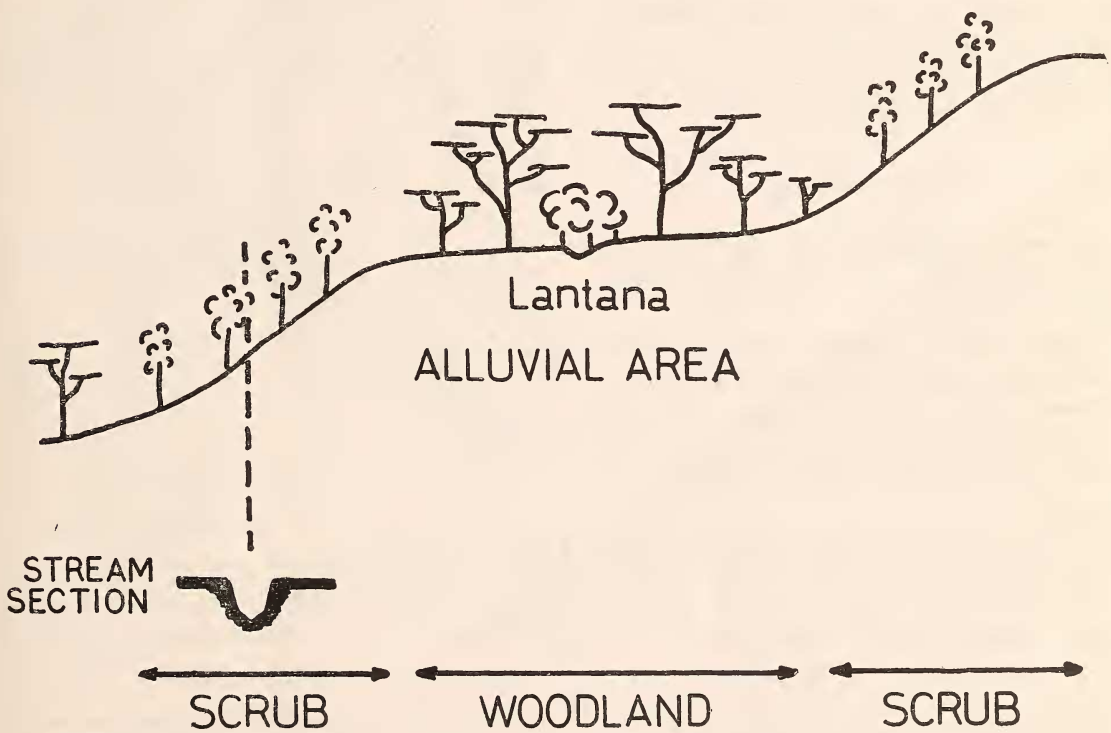

Fig. 1. Section WNW-ESE across the Ridge study area showing generalised pattern of vegetation in relation to slope. Vertical scale greatly exaggerated.

occurs commonly, scattered throughout this area, growing up to 8 m high, but nowhere forms dense stands.

Other shrubs which occur in localised patches are *Jatropha gossypifolia,* which grows on steep rocky places, and *Balanites roxburghii,* which grows in the level zone on the margins of the woodland, and apparently requires some depth of soil. Several dense clumps of *Lantana indica* occur where watercourses cross the level zone, and this shrub seems to prefer a combination of perennial moisture and some soil accumulation.

The herbaceous vegetation of the study area flourishes almost exclusively during the rainy season, which lasts from July to October. During this period open areas become clothed in grasses and other herbs, and shrubby perennials such as *Hibiscus micranthus* and *Tephrosia* spp. put out luxuriant growth.

Avian habitats

Four main vegetation types can be recognised in the study area as providing distinct habitats for birds:

1) Closed canopy woodland with an open understory, mainly of *Adhatoda vasica.*
2) Closed canopy woodland with a dense understory of *Carissa spinarum, Capparis sepiaria,* and *Lantana indica,* as well as *Adhatoda.*
3) Dense scrub with *Carissa spinarum, Securinega leucopyrus, Dichrostachys cinerea,* and *Anogeissus pendula* up to 3m high, with scattered *Butea monosperma.*
4) Low scrub dominated by *Zizyphus nummularia,* up to 1 m high, with scattered *Prosopis juliflora,* up to 5m high, and many bare rocky outcrops which support an ephemeral flora during the rains.

The distribution of these 4 vegetation types is shown in Fig. 2.

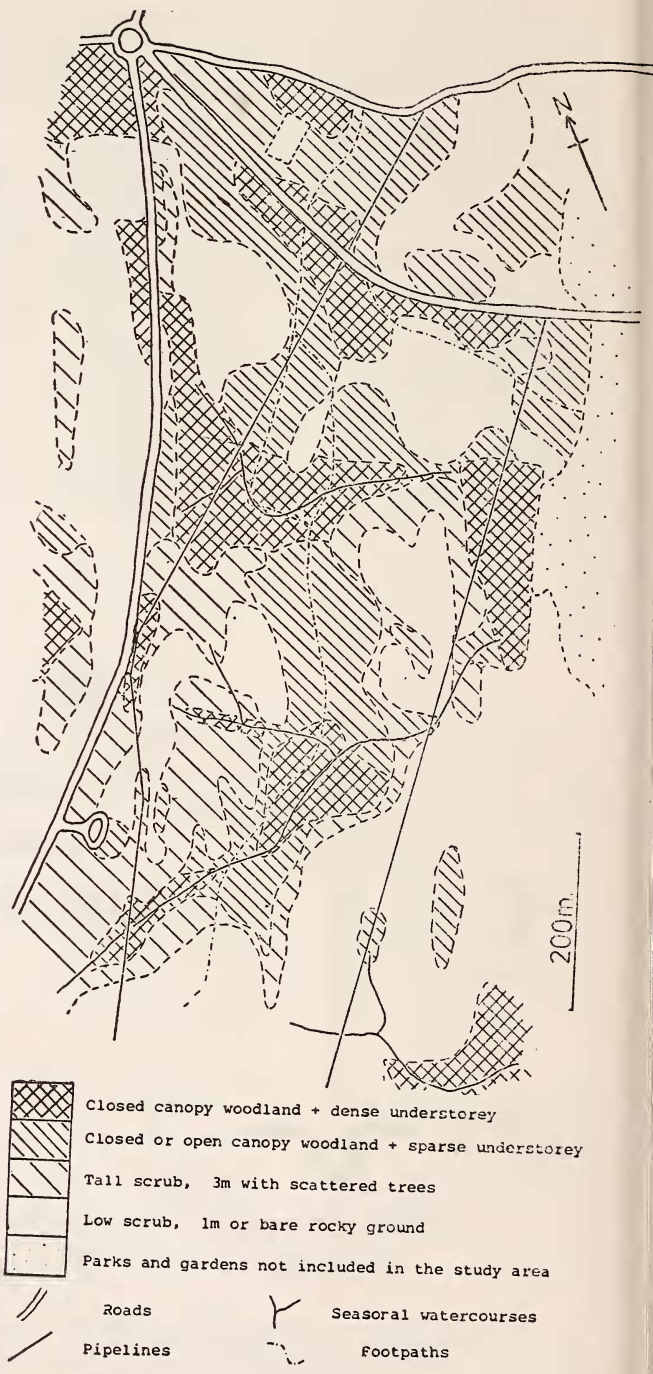

Fig. 2. Map of the Ridge study area showing the distribution of different vegetation types.

TABLE 1

DISTRIBUTION OF BREEDING BIRDS AND WINTER VISITORS AMONG FOUR DIFFERENT VEGETATION TYPES ON THE NEW DELHI RIDGE

Residents (R) & Summer visitors (SV)	Woodland + open understory		Woodland + dense understory	Tall scrub + *Butea*	Open scrub	Total types
Accipiter badius R	+		+	+		3
Butastur teesa SV	+			+		2
Francolinus pondicerianus R				+		1
Pavo cristatus R	+	G		+		2
Vanellus indicus SV					+	1
Burhinus oedicnemus R					+	1
Streptopelia decaocto R	+	G		+	+	3
S. tranquebarica SV	+	G	+			2
S. senegalensis R				+	+	2
Psittacula krameri R	+	C	+	+		3
P. cyanocephala R				+		1
Clamator jacobinus SV	+	SC	+	+	+	4
Cuculus varius SV	+	C				1
Eudynamys scolopacea SV		SC	+			1
Taccocua leschenaultii R				+		1
Centropus sinensis R		GS	+			1
Caprimulgus asiaticus SV				+		1
Merops orientalis R				+	+	2
Coracias benghalensis SV					+	1
Upupa epops R	+	G				1
Megalaima zeylanica SV	+	C	+			2
M. haemacephala SV	+	C	+			2
Dinopium benghalense R	+	T	+			2
Dendrocopos mahrattensis R	+	T	+	+		3
Mirafra erythroptera R					+	1
Lanius vittatus R	+	G		+		2
Lanius schach R				+		1
Dicrurus adsimilis SV	+			+		2
Sturnus pagodarum SV	+	G				1
Acridotheres tristis SV	+	G				1
Dendrocitta vagabunda R	+	SC	+	+		3
Corvus splendens R	+	CG		+		2
Tephrodornis pondicerianus R	+	C	+	+		3
Pericrocotus cinnamomeus R	+	C	+			2
Pycnonotus jocosus R		S*	+	+		2
P. leucogenys R				+	+	2
P. cafer R	+	SC	+	+	+	4
Chrysomma sinensis R		S*	+	+		2
Turdoides caudatus R				+	+	2
T. malcolmi R	+	G			+	2
T. striatus R	+	GT	+	+		3
Prinia hodgsonii R	+	SC	+	+		3

Residents (R) & Summer visitors (SV)	Woodland + open understory		Woodland + dense understory	Tall scrub + *Butea*	Open scrub	Total types
P. buchanani R				+	+	2
P. subflava R				+		1
P. socialis R		S	+	+		2
Orthotomus sutorius R	+	ST	+	+		3
Copsychus saularis R		G	+			1
Saxicoloides fulicata R	+	G	+	+	+	4
Nectarinia asiatica R	+	SC	+	+		3
Zosterops palpebrosa R	+	SC	+			2
Passer domesticus SV	+	C		+		2
Petronia xanthocollis SV				+	+	2
Lonchura malabarica R				+	+	2
Winter visitors						
Elanus caeruleus				+	+	2
Jynx torquilla				+		1
Lanius excubitor					+	1
Pericrocotus ethologus	+	C	+			2
Muscicapa parva	+	C	+			2
Sylvia hortensis		S	+	+		2
S. curruca	+	SC	+	+		3
Phylloscopus collybita	+	GSC		+		2
P. griseolus	+	GT	+	+		3
P. inornatus	+	C	+			2
P. subviridis	+	C	+			2
Phoenicurus ochruros	+	G	+	+		3
Turdus ruficollis		GS*	+	+		2
Carpodacus erythrinus				+		1
Emberiza stewarti				+	+	2

Woodland feeding zones: G; Ground T; Trunks S; Shrubs C; Canopy
*; species associated particularly with dense stands of *Lantana indica*

TABLE 2

THE NUMBER OF BIRD SPECIES FOUND IN EACH VEGETATION TYPE

		Non-passerine	Passerine	Total	Resident	Ratio Res/ Nonres.
(1) Woodland + open understory	Summer	13(43%)	17(57%)	30	20	1.11
	Winter	7(25%)	21(75%)	28		
(2) Woodland + dense understory	Summer	10(42%)	14(58%)	24	19	1.35
	Winter	5(18%)	23(82%)	28		
(3) Dense scrub	Summer	13(37%)	22(63%)	35	29	1.81
	Winter	12(31%)	27(69%)	39		
(4) Open scrub	Summer	7(47%)	9(53%)	16	12	1.5
	Winter	6(33%)	10(67%)	16		

Distribution of bird species in relation to vegetation types

Because of the small size of the study area relative to the mobility of most birds, practically all species were seen in all 4 vegetation types at one time or another. Table 1 shows the distribution of nesting and wintering species among the vegetation types, judged on the basis of their preferred feeding habitats during the breeding season (resident species and summer visitors) or winter (winter visitors). Resident species generally seem to move about more outside the breeding season, when food is probably least abundant.

Species found in the 2 woodland vegetation types are further classified according to their preferred feeding niches; ground (G), shrub (S), trunk (T) and canopy (C). Those species particularly associated with the occurrence of dense clumps of *Lantana indica* are also indicated.

Omitted from Table 1 are 3 species which occur in the study area only in the vicinity of water: *Halcyon smyrnensis* (resident), and *Erithacus svecicus*, and *Motacilla cinerea* (winter visitors).

Table 2 shows the number of species found in each vegetation type, and the ratios of passerine to non-passerine species. The largest number of species is found in the dense scrub (type 3). This may be because it is intermediate in character between the woodland and the open scrub, but its floristic composition is relatively diverse, and must resemble the original flora of the area more closely than do the other 3 vegetation types.

In all except vegetation type 4, bird species diversity is greater during the winter than during the breeding season. This is due to an influx of passerine species during the winter. While there is a 28% increase in passerines, there is a decrease of 33% in the number of non-passerine species.

The increase in passerine species is most marked in the two woodland habitats which show 24% (1), and 64% (2) increases. The other two habitats show increases of 23% (3) and 11% (4). The numbers of non-passerine species in the two woodland habitats fall by 46% (1), and 50% (2) respectively, while in the other two habitats they decrease by 8% (3) or by 14% (4).

At first sight these figures suggest a replacement of breeding non-passerine summer visitors by passerine winter visitors, but the two groups tend to occupy quite different niches. The majority of passerine winter visitors are small insectivorous birds, and 7 of the 11 found in woodland feed partly or wholly in the canopy. In fact this feeding zone shows a 78% increase in passerines between summer and winter. The non-passerine summer visitors, on the other hand include only two insectivorous species, *Clamator jacobinus* and *Cuculus varius*, among those found in woodland. The rest fall into two categories:
a) frugivorous species: *Eudynamys scolopacea*, *Megalaima zeylanica* and *Megalaima haemacephala*. b) moderate-large insectivorous species found in scrub; *Caprimulgus* spp., *Merops orientalis*, and *Coracias benghalensis*.

Seasonal turnover of Species

Thirty-eight species are resident in the study area throughout the year. This number does not include species such as *Pernis ptilorhynchus*, *Milvus migrans*, *Gyps benghalensis*, *Neophron percnopterus*, and *Spilornis cheela* which are seen throughout the year, but which are not known to nest in the area.

Fourteen species are summer visitors, and sixteen winter visitors. The overall ratio of resident: non-resident species is 1.33.

Tabel 2 gives the ratios of resident: non-resident species for the four vegetation types separately. This ratio is lowest in the woodland habitats where turnover of species is highest, and highest in the scrub, where most species are resident. This observation parallels the findings of MacArthur (1959) for 29 stations across North America, where he found the proportion of resident species to be lower in woodlands than in open habitats at the same latitude.

The higher proportion of winter visitors in the woodland around Delhi may be a corollary of the situation which MarArthur found in temperate North America. As more species leave woodland habitats in the temperate zone during the winter they might be expected to seek similar habitat in their winter quarters. The greater turnover in the woodland avifauna around Delhi may not necessarily, therefore, reflect differences in the seasonal abundance of food in different vegetation types.

Local Migrants

Among species classified as summer and winter visitors in Table 1, several are only local migrants, and are found throughout the year in areas adjacent to the ridge. The summer visitors which come in this category are *Butastur teesa, Streptopelia tranquebarica, Merops orientalis, Coracias benghalensis, Megalaima zeylanica, Megalaima haemacephala, Dicrurus adsimilis, Sturnus pagodarum, Acridotheres tristis,* and *Petronia xanthocollis.* This includes all the passerine summer visitors. Among winter visitors *Psittacula cynaocephala,* and *Lanius excubitor* both breed around Delhi, and their presence on the ridge during the winter may reflect a general dispersal at this season.

Table 3

The numbers of bird species occupying 1, 2, 3 and 4 vegetation types

	No. of species occupying x vegetation types				Mean vegetation types/species		Totals
	1	2	3	4			
Passerines—							
Resident	4	12	6	2	2.25		24
Non-resident	3	3	0	0	1.50	1.89	6
Palaearctic winter visitors	2	7	3	0	2.08		12
Non-passerines—							
Resident	7	4	4	0	1.81		15
Non-resident	5	5	0	1	1.62		11
Total	21	31	13	3	1.97		68
	a		b				

Testing the proportion of group a (narrow habitat preference) species to group b species, among both passerines and non-passerines $X^2 = 4.6$, $p < 0.05$. Comparing resident to non-resident species, using passerines and non-passerines combined, $X^2 = 0.44$, $p > 0.5$.

Degree of Specialisation in Habitat Selection

The number of different vegetation types occupied by a species can be treated as a measure of the degree to which the species is specialised in that dimension of its ecological niche. The mean number of vegetation types occupied, calculated for all species, is 1.97. Only two resident species, *Pycnonotus cafer*, and *Saxicoloides fulicata* occupy all four (see Table 3), as does the summer visitor *Clamator jacobinus*.

Passerine species seem to be less specialised in this respect than non-passerines. Among passerines 9 out of 42 species are found in only one vegetation type, while the corresponding proportion for non-passerines is 12 out of 26 ($\chi^2 = 4.6$, $p < 0.05$).

This supports the hypothesis put forward by Klopfer & MacArthur (1960), suggesting that non-passerine birds, being more stereotyped in their behaviour than passerines, occupy smaller niches.

Another suggestion, forming part of the same hypothesis, is that tropical passerines show greater specialisation, and therefore occupy smaller niches than temperate passerines. This is not supported by a comparison of the mean number of vegetation types occupied by resident passerines, with the same index for palaearctic winter visitors. The means are practically identical (2.25, 2.08). The habitat preferences of the resident species are assessed on the basis of their distributions during the breeding season, however, and many species tend to range further afield during the winter. The average resident may actually be less specific in its habitat requirement than the average winter visitor during the period when the two groups co-exist.

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